

CHAPTER 4: IMPACT ANALYSIS

Impacts to agricultural systems, and to other aspects of the land resource, are evaluated in this section.

It should be noted that for this analysis, it has been conservatively assumed that undiluted CBM water will be used year-round. The low rates of flow from most CBM wells would likely permit the blended or intermittent use of CBM water, which could reduce or eliminate the level of impacts suggested in this analysis. The use of CBM water for irrigation will also be limited to the growing season for the intended crops, which usually ranges from 100 to 150 days per year.

4.1 AGRICULTURAL IMPACTS

The main agricultural land uses evaluated here are livestock watering and irrigation. Appendix B presents several fact sheets prepared by the Montana State University Extension Service. These Ag Notes cover such topics as irrigating with saline water, soil erosion, soil quality, management of saline and sodic soils, suitability of water for livestock, and soil salinity crop and forage tolerances. Some of these documents were used to prepare this section, and all can be used as additional sources of information.

4.1.1 Agricultural Irrigation

Potential impacts from agricultural irrigation with CBM water are related to the quality of the water. To determine these impacts, the quality characteristics of the CBM water can be compared to generally accepted irrigation water quality requirements (Ayers and Westcot 1985). The quality categories are discussed and compared to the previously presented CBM water quality characteristics as follows:

Salinity (*affects crop water availability*): The principal measure of salinity of irrigation water is EC expressed in deciSiemens per meter (dS/m). (Note: 1 dS/m = 1 mmhos/cm). Crops vary in their response to irrigation water salinity as follows:

?? < 0.7 dS/m	provides no restrictions to crop growth
?? 0.7 – 3.0 dS/m	provides slight to moderate restrictions to crop growth
?? > 3.0 dS/m	provides severe restrictions to crop growth

From Exhibit 2, the lowest, mean (average), median, and highest salinities of the CBM water are 0.47, 1.3, 1.13, and 3.02 dS/m, respectively. From Exhibit 3, the average salinity of the CBM water from the 19 Decker wells is 2.39 dS/m. Based on these values, CBM water with salinities equal to those of the indicated lowest and average salinities would pose no significant problem even for most sensitive crops. CBM water with the highest indicated salinity may pose problems only to some moderately sensitive to moderately tolerant crops.

The tolerances to salinity of six example crops grown in the study area are shown in Exhibit 7. In developing the basic data used for Exhibit 7, Ayers and Wescott (1985) assumed a leaching fraction of 15 percent to 20 percent. The line indicating 95 percent of potential yield is also shown. Since the basic data are somewhat

empirical, and since many other elements of the crop environment can also effect yield, it is considered reasonable that comparisons can, from a practical standpoint, be made using this indicated level of yield as a no-impact point. It is doubtful that such a yield decrement could be detected as attributed only to the level of salinity in the soil. Also from a practical standpoint, it is likely that farmers will alter their management practices (i.e., ensuring adequate leaching or selecting appropriate crop cultivars) to fit the specific conditions that occur to maximize the crop yield.

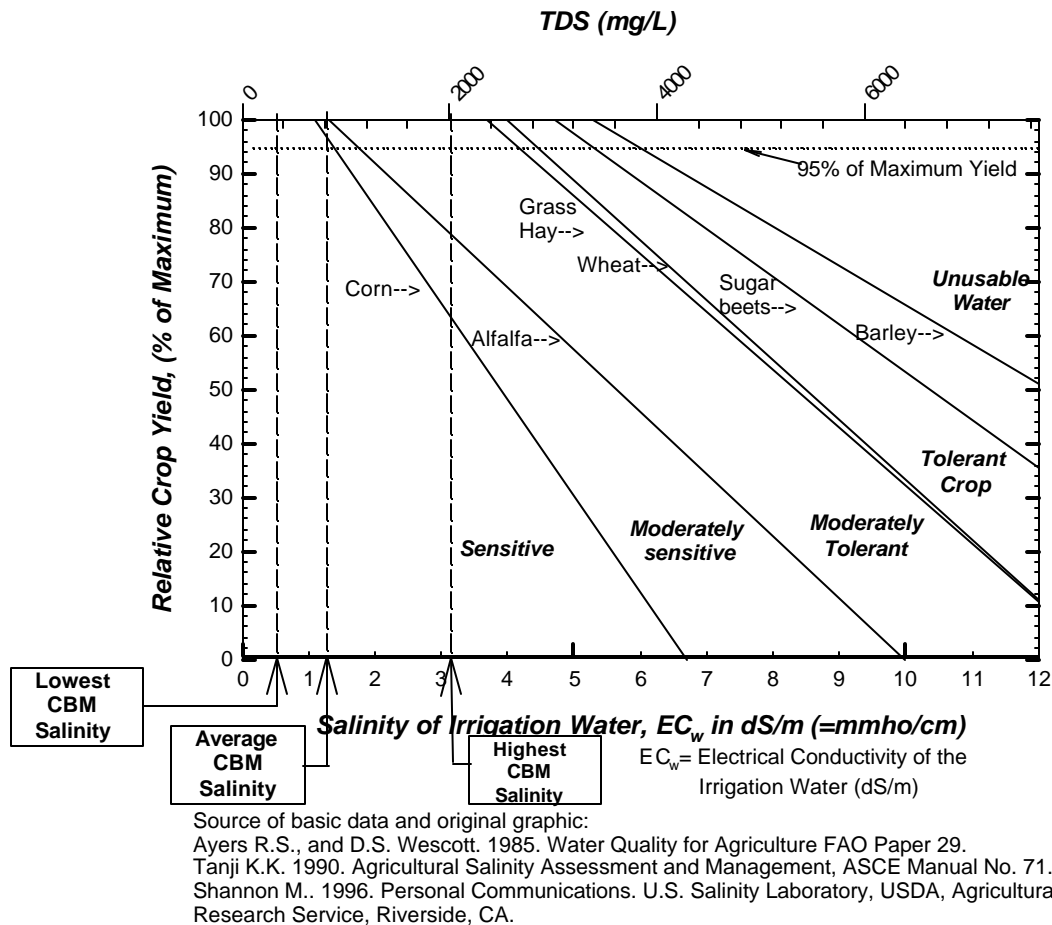


Exhibit 7. Relationship Between Relative Crop Yield and Irrigation Water Salinity for Six Sample Crops

With normally accepted management practices, the lowest CBM water salinity would have no adverse effect on the example crops. For the more salinity-sensitive of the example crops, such as alfalfa and corn, the salinity level of the average CBM water is near the threshold of causing yield reduction, and care would have to be taken to ensure adequate leaching. Also, a portion of the irrigation water supply may have to come from other sources, probably current irrigation water sources. From the standpoint of salinity, the other example crops should do well with any of the indicated CBM water as a sole source for irrigation, provided the soil has good internal drainage and normally acceptable

management practices are followed. Prospective irrigators should be provided with this information in order for them to make the decision if they can accept a possible yield reduction, or possible increase in the case where a crop goes from dryland to irrigated.

SAR (Sodicity) (*affects infiltration rate of water*): Generally, increasing levels of SAR create an increasing hazard for infiltration problems. However, if the irrigation water contains higher levels of salinity, the SAR can increase without greatly increasing the infiltration hazard. Therefore, both the SAR and the EC of the irrigation water are used to evaluate potential infiltration problems. Usually, SAR values below 3.0 are not considered to be a threat to crops and native plants; however, SAR values above 12.0 are considered sodic and may affect soils and vegetation.

Exhibit 8 shows the potential infiltration hazard of the average CBM water quality from Exhibits 2 and 3. Such water may cause a slight to moderate reduction of the rate of infiltration of water into the soil. Also shown in Exhibit 8 are the individual CBM waters (Rice et al, 2000) with the lowest and highest salinity (EC) with their corresponding SAR, and those with the lowest and highest SAR and their corresponding EC. The individual waters with the highest SAR and lowest EC could cause a significant reduction in the infiltration rate if the waters were used continuously as the only water supply. The individual waters with the lowest SAR and the highest EC would likely cause only a slight to moderate reduction in the infiltration rate of the soil.

Trace Elements (*affects crop toxicity*): Certain trace elements in the irrigation water can cause toxicity in certain crops. Ayers and Westcot (1985) present recommended maximum concentrations of trace elements in irrigation water. A comparison of these recommended maximum concentrations to the highest concentrations presented in Exhibit 2 showed that, in every case, the highest concentrations of the CBM waters were considerably lower, in most instances by one to three orders of magnitude, than the recommended maximums.

4.1.2 Livestock Watering

As with plants, certain trace elements in drinking water can be toxic to livestock. Ayers and Westcot (1985) present water quality guidelines for livestock. A comparison of these water quality guidelines to the highest concentrations of the CBM waters in Exhibit 2 and the average concentrations of the CBM water in Exhibit 3 indicated that all of the CBM waters would be very satisfactory to excellent for use as livestock drinking water. In some cases, the water could cause temporary diarrhea in livestock not accustomed to such water, but this problem should rapidly disappear as animals adapt to the new water supply. Ag Note 146 - *Suitability of Water for Livestock* in Appendix B also provides information pertaining to suitable water for livestock.

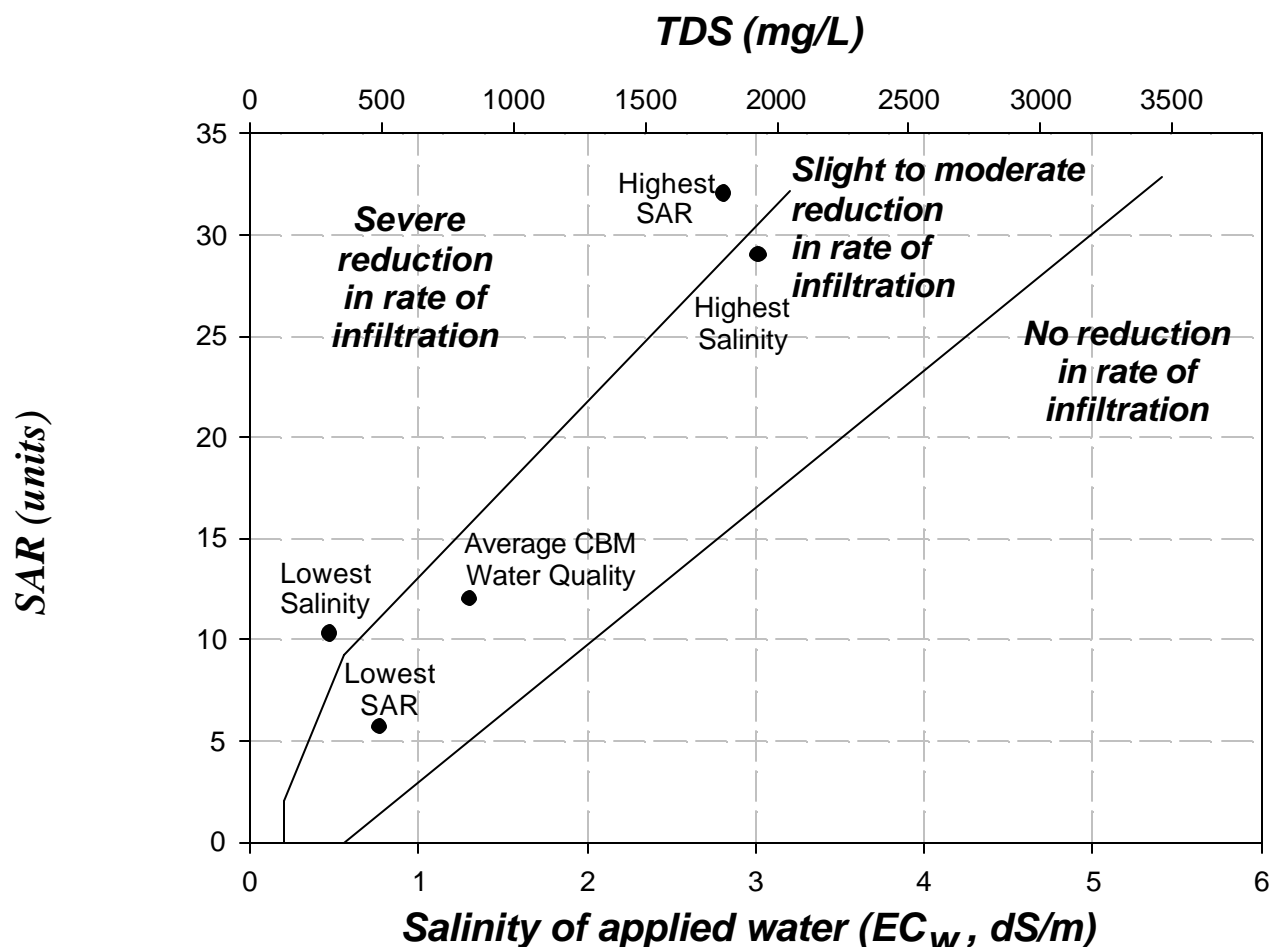


Exhibit 8. General CBM Water Quality Relative to the Potential for Dispersion of Soil Aggregates and Reductions in Soil Rate of Infiltration (Based on data from Ayers and Westcot 1985)

4.2 OTHER IMPACTS

In addition to supplying water to plants or livestock, landspreading or surface discharge of the CBM water can cause undesirable impacts. Where irrigation water is otherwise unavailable or not supplied, discharge of CBM water to land would have the benefit of providing water for plant growth. With the higher salinity CBM waters shown in Exhibits 2 and 3, long-term landspreading would likely increase the salinity and sodicity of the affected surface soils and hence adversely affect the native vegetation and wildlife habitat. This could lead to an increase in primary productivity of plant communities adapted to this new hydrologic condition or changes in the existing plant community in response to the new hydrologic regime. Resulting communities and habitat would necessarily be adapted to the quality of water from the specific CBM source wells. This could lead to subsequent changes in the wildlife community to one adapted to salt-tolerant plant communities. Accumulation of evaporated salts could also occur in any closed depressions, which would destroy vegetation in these

depressions. Such long-term discharge to the land surface could also cause excessive erosion of the soil and gullyng, which could intensify over time if high SAR water reduced infiltration. With long-term discharge of high salt CBM water to constructed evaporation ponds, removal and disposal of the accumulated salts would likely be required.

With discharge of the CBM water to surface drainageways and streams, serious erosion could occur, damaging or destroying instream vegetation (Bauder 1999). The erosion can result in increased sediment loads, which along with the potential high salinity and sodicity, can significantly degrade the stream and receiving water quality. This degraded quality could also affect the biological aspects of the stream. It is also important to note that, depending on the quantity and level of quality of the discharged CBM water, the receiving waters could significantly dilute the concentrations of the constituents in the CBM water, resulting in potentially minimal impact from salinity on the receiving waters. Of course this would depend on the amount of CBM water released in relation to the flow in the receiving water bodies. Bauder (1999) presented a scenario based on the assumption that 100 CBM wells producing 10 gallons per minute (gpm) each for a total of 2.2 cubic feet per second (cfs) were discharging into the Tongue River near Decker, Montana. The mean flow of the river at the lowest period is about 180 cfs, and during the high flow it is about 1,680 cfs. In terms of volume of water, the CBM water discharges are likely to be insignificant compared to the normal flows of the Tongue River. On the other extreme, the RFD produced by the Miles City, Montana, BLM in 2001 gives the full field development of a maximum of 26,000 wells in the next 20 years. At an average flow of 10 gpm per CBM well, this would be approximately 580 cfs (1,150 ac-ft/day), which could make a significant impact on the environment.

The construction and continued use of the CBM wells and gas production facilities, the network of roads and pipelines, and storage ponds can cause significant impacts to the local resources. The actual surface disturbances and use of the facilities can cause erosion of the soils and introduction of noxious weeds to the surrounding area. The existence of the facilities reduces the forage base for livestock and wildlife. The activities during use of the facilities can also adversely affect the activities of the various native wildlife species.

4.3 LONG TERM EFFECTS

The long-term impacts of using CBM water or diluted discharge water for agricultural purposes include crop effects, farming practice changes, irrigation management, and direct effects to soils. However, with proper crop selection and appropriate irrigation management, economic yields can be sustained under low to moderate saline conditions.

The use of high salinity/sodium CBM water may have long-term effects on crops. There may be limitations on which crops species can viably be grown. More salt tolerant crops may have to be grown where higher salinity irrigation water is used, such as barley and sugar beets, and hays such as Bermuda, wheatgrass and wildrye, instead of the more salt sensitive plants like wheat, alfalfa, corn, and clover hay. Some crops may show toxic effects of salts accumulating in the leaves or rootstock over time. This is most common in trees and other woody perennials.

Another long-term effect of using high salinity CBM water may lead to the modification of cropping practices. This may include such practices as modifying seed placement (e.g., planting on furrow sides, double-row raised beds, increasing seeding rates, etc.) to achieve better germination and stands; new or modified equipment for crop sowing; growing different crops; soil profile modification for better drainage and water penetration; and the use of amendments such as gypsum or sulfur to soils to improve water permeability lost to excess sodium in the soil.

Soils do not usually become excessively saline from use of saline water in a single irrigation season, depending on the quality of water used. It may even take several irrigation seasons to affect the level of salt in the soil solution. The maximum soil salinity in the root zone that results from continuous irrigation with saline water does not occur when salty water is used only a fraction of the time. Changes may need to be made to irrigation water management techniques required to use CBM water. The method of application of irrigation water may need to change. Areal application with sprinkler irrigation can cause concentrated salt accumulations near the soil surface and cause foliar damage to certain plants. Other types of application such as drip and furrow irrigation have less salt accumulation at the soil surface in the shorter term, but still may result in salt accumulations in deeper soils over the longer term. Additional irrigation water will be required for leaching to ensure salts are moved out of root zone. Increasing the frequency of irrigation may also need to be implemented to maintain soil water content and decrease the effects of applying saline water (less water holding capacity and higher salinity levels). These increases in irrigation water amounts may lead to producers having to file for additional water rights or finding other sources of lower salinity water for leaching, and a potential for more saline seeps in areas irrigated with CBM water.

The cumulative effects of the application of high SAR CBM water to the soil and the build up of sodium will have an affect on the physical characteristics of the soils -which in turn affect the chemical characteristics – and then the biological characteristics. It is possible to create a site through sodium saturation which will not support the production of very many plant species. This is not so much a consequence of the sodium as it is a consequence of the externalities, i.e., the things that come about when the soil is saturates with sodic water and it disperses (deflocculates). This includes a shut down of the water and gas exchange processes. The soil is likely to go from an aerobic situation to an anaerobic (oxygen devoid) system. High SAR/sodic water should not be applied to fine textured, slow infiltration, poorly drained soils. This would include silts, clays, silt loams, silty clay loams, clay loams, sandy clays. These soils are dependent on good structure for infiltration. If sodic water is applied to these soils, the probability of soil dispersion (deflocculation) is high. Once the soil disperses, infiltration and drainage decrease. The long-term consequence is an anaerobic, waterlogged, saline/sodic soil. These soils can be reclaimed, but the requirement is engineered drainage and the application of excessive amounts of gypsum, sulfur, and good quality water - and the discharge of the sodium laden drainage water.

Because of its lack of structure and vegetation, dispersed soil is very susceptible to erosion. Depending on the location of the CBM water discharge and the drainage course, a normal rain or storm event could easily provide the flow rate and runoff necessary for erosion on a large scale of the already dispersed, saturated, sodic soils.

The soil's dispersion takes place through out the profile. So, the erosion will continue to a point where the profile has not been exposed to the sodic water or it reaches a basement pavement structure that cannot be dispersed or eroded, like coarse gravels or bedrock. In any single drainage, the above scenario could take place repeatedly with down cutting and erosion that would continue until the soil profile is completely eroded away and what is left behind is a "V" shaped cut with bedrock in the bottom. Water will also infiltrate within the ephemeral channels and streambanks, which will contribute to increased erosion in the drainages over time. Another long-term effect includes saline seeps that may appear on lower terraces, river banks, and below impoundments where high SAR water flows or is stored. This may result in varying degrees of adverse effects on vegetation, consumers of that vegetation, the soil, and water quality of any streams receiving salts from such seeps. The native species composition in these effected areas will also change. CBM water discharge will have the cumulative effect of encouraging the establishment and proliferation of non-native and noxious weed species like Salt Cedar that thrive and dominate under high sodic/salt conditions.

Development of a sodium hazard usually takes time. Soil tests for SAR or percent exchangeable sodium can detect changes before permanent damage occurs. Proper management can maintain SAR and salinity values at a steady state below threshold levels.